한국기계가공학회지, 제18권, 제12호, pp.22～27(2019.12) ISSN 1598-6721(Print)
Journal of the Korean Society of Manufacturing Process Engineers, Vol. 18, No. 12, pp.22~27(2019.12) ISSN 2288-0771(Online)

https://doi.org/10.14775/ksmpe.2019.18.12.022

# Flow Analysis due to the Angle of the Front Wing on an Airplane

Moonsik Han*, Jaeung Cho**,#

*Department of Mechanical and Automotive Engineering, Keimyung UNIV.
**Division of Mechanical and Automotive Engineering, Kongju National UNIV.

# 비행기에서의 앞날개의 각도에 따른 유동해석

한문식*, 조재웅**,#

*계명대학교 기계자동차공학과, **공주대학교 기계자동차공학부

(Received 18 June 2019; received in revised form 22 June 2019; accepted 7 July 2019)

## ABSTRACT

In this study, the flow rate and air resistance pressure were analyzed on models a, b, and c due to the front wing angle of the airplanes. Models a, b, and c have front wing angles of 120°, 100°, and 160°, respectively. The results of the flow analyses showed that the flow rate and air resistance pressure of model c were observed to be higher than models a and b. The airplane model with a larger angle to the front wing is thought to be the best model for flight. This result can be applied to development of the best in-flight airplane.

**Keywords :** Airplane(비행기), Flow Analysis(유동해석), Front Wing Angle(앞날개 각도), Air Resistance Pressure(공기 저항 압력), Structural Analysis(구조해석)

## 1. Introduction

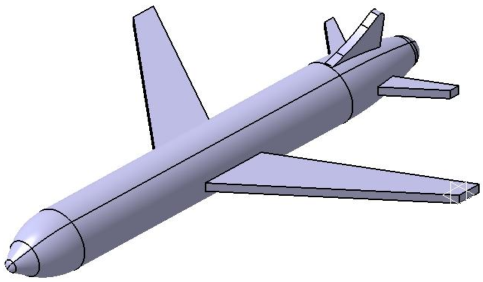
The oversea market can be seen to increase to meet the global era of the 21’st century, and the negotiations with various countries. In order to satisfy this demand, the transportation to and from overseas quickly and conveniently is an important way. A typical example among these means of transportation is the airplane. The wings of this airplane are those that have the ability to fly artificially with the air pressure from both sides. The flight principle of airplane is based on the law of gravity. This principle of airplane that can overcome this gravity force and fly in the sky can be seen mainly to be lift, momentum, resistance, and gravity[1-15]. The most important thing in a plane's flight is its lift. The greatest advantage of airplane's wings is that it generates the greatest force of lift when it flies, indicating that the structure of airplane's wings is the most important element during airplane's analytical simulation process.

# Corresponding Author : jucho@kongju.ac.kr
Tel: +82-41-521-9271, Fax:+82-41-555-9123

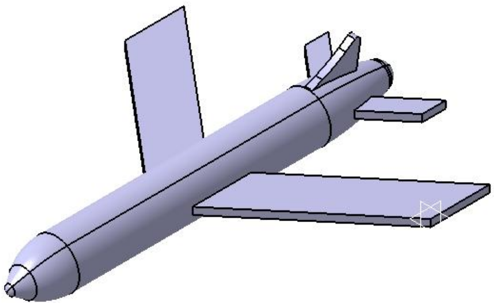
## 2. Analysis Result

### 2.1 Analysis models

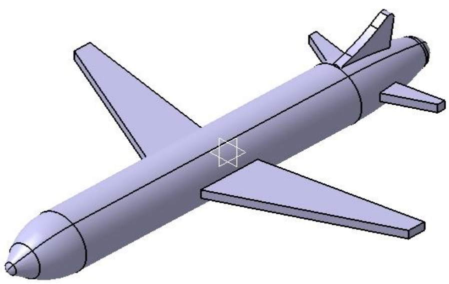
In this study, the wing angles of models A, B and C are 120°, 100° and 160° respectively. After modeling, the CFX analysis was conducted[4-6]. The structural analysis was carried out to investigate the pressure and speed of the airplane applied by the flow according to the wing angle of the airplane. Fig. 1 shows the design models of A, B and C used in this study.



**(a) Model A**



**(b) Model B**



**(c) Model C**

**Fig. 1 Design models in this study**

**Table 1 Numbers of meshes on models A, B and C**

| Model | Nodes | Elements |
|---|---|---|
| Model A | 15241 | 81485 |
| Model B | 15372 | 82015 |
| Model C | 15093 | 80706 |

**Table 2 Material property of AL7075-T6**

| | |
|---|---|
| Young's Modulus(GPa) | 71.71 |
| Poisson's Ratio | 0.33 |
| Density(g/cc) | 2.81 |
| Tensile Yield Strength(MPa) | 503 |
| Tensile Ultimate Strength(MPa) | 572 |

### 2.2 Comparison of finite element models A, B and C

In this study, Table 1 shows the number of elements at the meshes of models A, B and C generated through finite element method. Table 2 shows the material property of AL7075-T6 on aircraft body used in the study.

### 2.3 Flow analysis

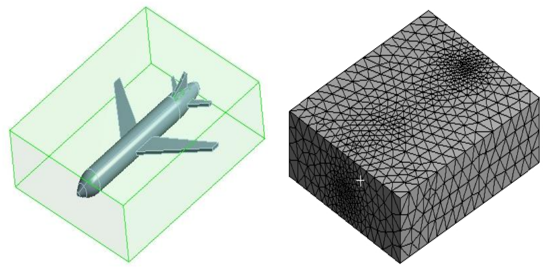
Each flow area on models A, B and C was designated as the fluid enclosure in box format. The inlet speed of flow was given at 700 km/hr and the outlet pressure was applied at 1 atm. Fig. 2 shows the fluid box enclosures of models A, B and C with meshes.

Fig. 3 shows the contours of magnitude and direction on air flow rate for each model. The highest flow rates at all models are shown in the middle wing of the end wing of the airplane. The highest flow rate at models A, B and C become 320.452 m/s, 319.981 m/s and 320.995 m/s respectively.

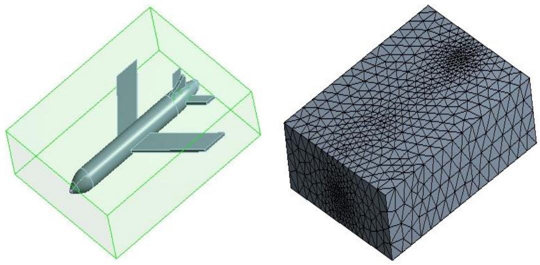
Fig. 4 shows the contours indicating air resistance pressure at each model. The air resistance pressures of all three models became the highest on the head side of the airplane.

The highest pressures at models A, B and C become 131857Pa, 132271Pa and 132583Pa respectively. Model C was shown to be the airplane model with the wing angle that is most resistant to air resistance pressure.

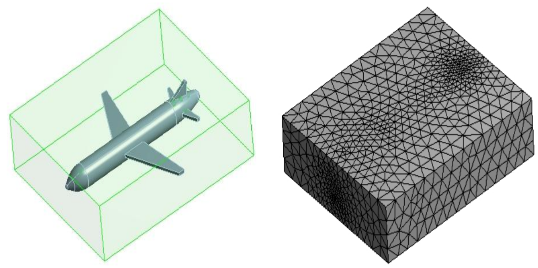
Fig. 5 shows the contours about the air resistance pressure of the airplane on the mid-plane at each model, with the highest pressure of 131857 Pa for model A, 132271 Pa for model B and 132583Pa for model C. This figure shows that model C is an airplane model with the wing angle that is most resistant to air resistance pressure.



**(a) Model A**

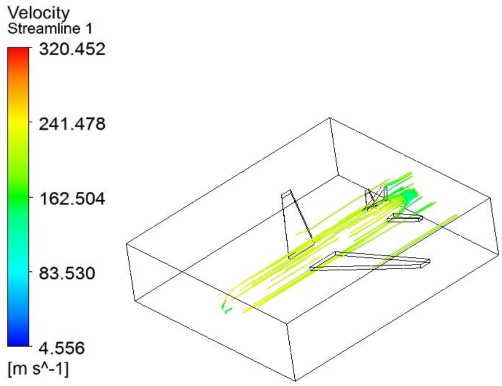


**(b) Model B**

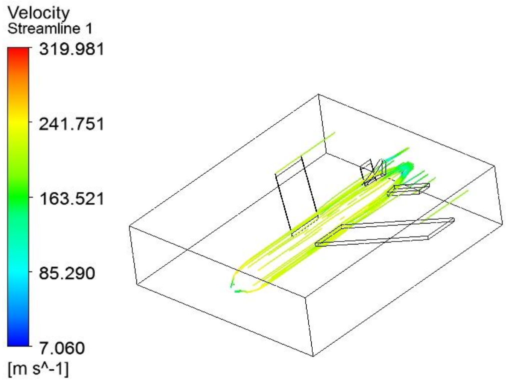


**(c) Model C**

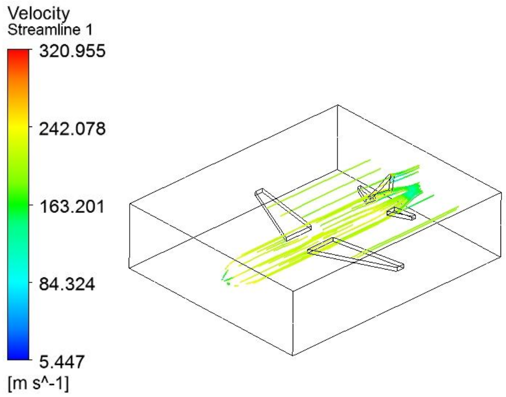
**Fig. 2 Fluid box enclosures of models A, B and C with meshes**




**(a) Model A**

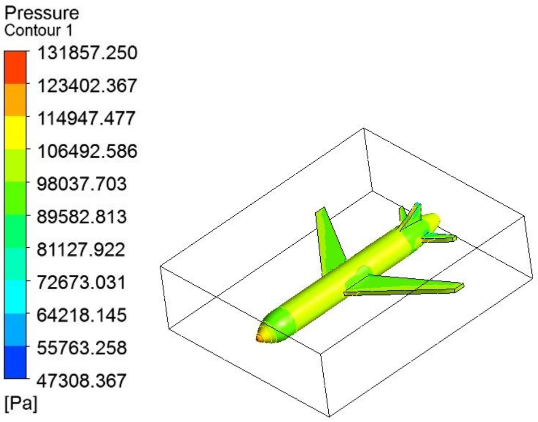



**(b) Model B**

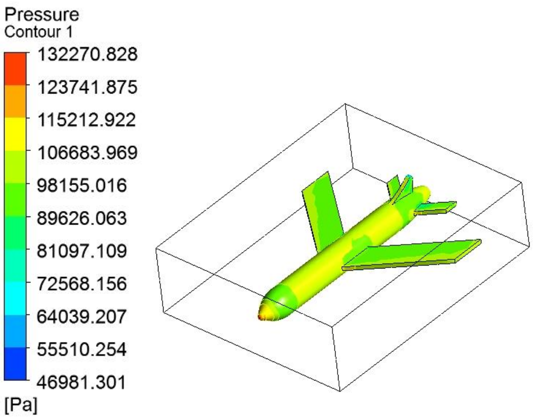



**(c) Model C**

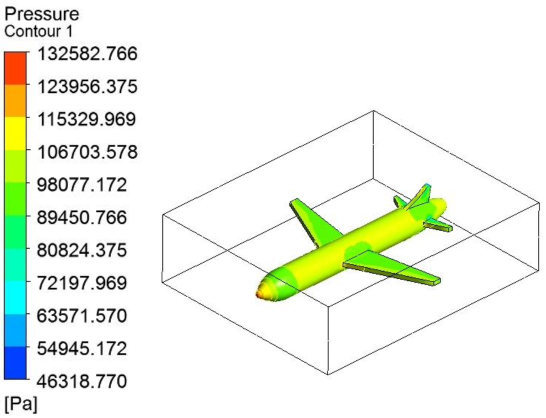
**Fig. 3 Contours of air flow rate for each model**




**(a) Model A**

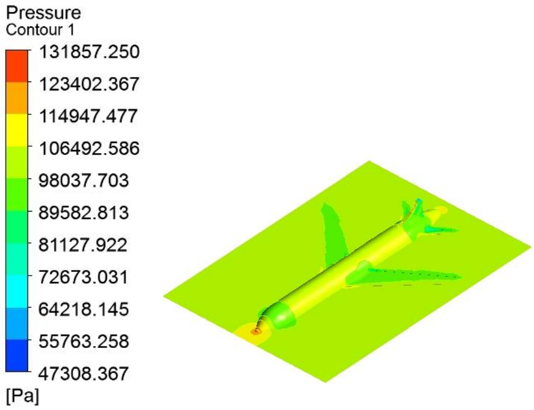



**(b) Model B**

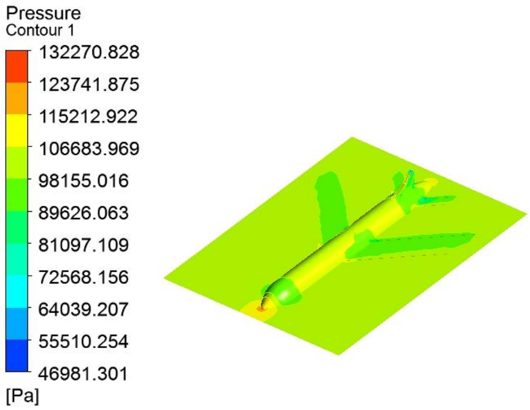



**(c) Model C**

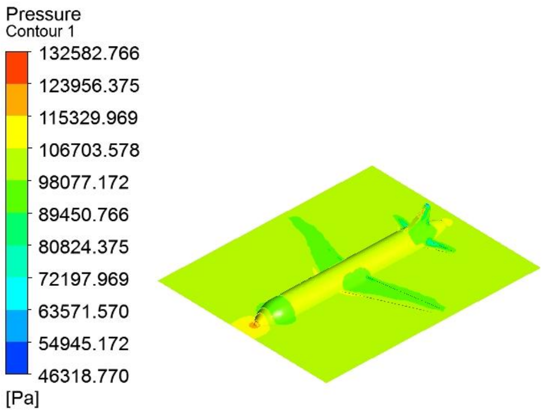
**Fig. 4 Contours of air resistance pressure at each model**




**(a) Model A**

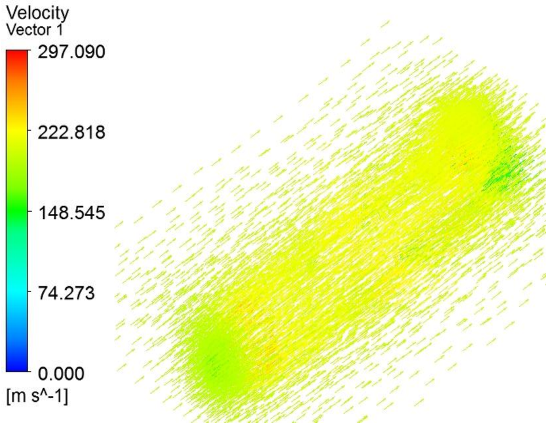



**(b) Model B**

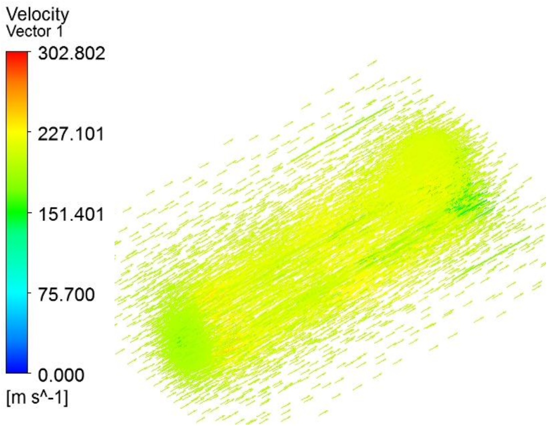



**(c) Model C**

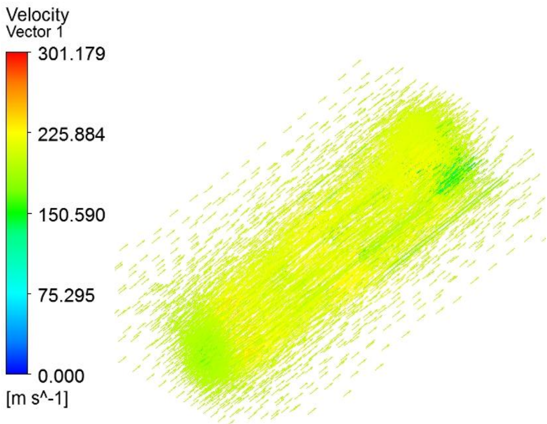
**Fig. 5 Contours about the air resistance pressure of the airplane on the mid-plane at each model**




**(a) Model A**




**(b) Model B**




**(c) Model C**

**Fig. 6 Contours with the vectors of air flow velocity at each model**

Fig. 6 shows the contours drawn with the vectors representing the direction of air flow velocity for each model. The highest flow rate for each model was 297.09 m/s for model A, 302.802 m/s for model B and 301.179 m/s for model C. Model B is shown to be the airplane model with the front wing angle as the fastest air flow rate.

## 3. Conclusion

In this study, the flow analysis was carried out with the fluid model according to the plane's wing angle. The main conclusions obtained from these analyses are as follows;

1. The air flow rate of each model was the largest at the rear mid-wing of the airplane. The air flow rate became 302.995 m/s at model C with the largest wing angle among the three models, so it is believed that the larger the angle of the wing, the greater the flow velocity of the airplane.
2. The air resistance pressure of each model was found to be the highest pressure in the head of the airplane, regardless of the angle of the wing. Among the three models, the highest pressure of 132583MPa can be seen in the model C where the angle of the airplane wing is the largest. The larger the angle of the airplane wing, the airplane wing is thought to be the best structure to withstand the air resistance pressure.

## REFERENCES

1. Kim, Y. C., Kim, Y. S., Kim, J., Kim, K. S., “Application of the Overset Grid Scheme (Suggar++) for Flow Analysis around a Ship,” Journal of the Society of Naval Architects of Korea, Vol. 56, No. 1, pp. 47 – 57, 2019.
2. Lee, Y. G., Park, I. H., Shin, J. H., Kim, S.,

Lee, K. Y., Choi, Y. S., "Mixed-Flow Pump Impeller-Diffuser Optimization Method by Using CFX and HEEDS," Transactions of the Korean Society of Mechanical Engineers B, Vol. 39, No. 10, pp. 831-842, 2015.
3. Ryou, H. S., "Calculation of Two-Dimensional incompressible Turbulent Flow Along the Aerofoil," Journal of the Korean Society for Aeronautical & Space Sciences, Vol. 18, No. 4, pp. 9-24, 1990.
4. Kim, C. H., Youn, C. B., "Aerodynamic Effect of Roof-fairing System on a Heavy-duty Truck," International Journal of Automotive Technology, Vol. 6, No. 3, pp. 221-227, 2005.
5. Park, J. Y., Baek, S. H., Kang, J. H., "Design Criteria of Spring Stiffness for Pan Check Valve Using CFD Analysis," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 13, No. 3, pp. 49-55, 2014.
6. Cho, J. U., Han, M. S., "Study on Flow and Stress Analysis of Gas Turbine Blade," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 10, No. 3, pp. 67-72, 2011.
7. Yun, J. H., Jeong, I. G., Yi, C. S., Suh, J. S., "Flow Characteristics due to Cutoff Angle of Turbo-Fan for Industries," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 10, No. 5, pp. 91-96, 2011.
8. Yi, C. S., "Numerical Analysis of the Kitchen Hood Ventilation System for Marine Environment," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 14, No. 5, pp. 96-101, 2015.
9. Ku, H. K., Kim, J. W., Won, C., Song, J. I., "Optimization and Structure Analysis of Brake Disc for Free-fall Winch," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 11, No. 3, pp. 55-61, 2012.
10. Wang., Z. H., Chun, C. K., Kwon, Y. C., "Study on Exhaust Air Heat Transfer Characteristics of Heat Exchange System for White Smoke Reduction," Journal of the Korean Society of Mechanical Technology, Vol. 20, No. 6, pp. 739-744, 2018.
11. Choi, Y. S., Kwon, Y. C., "An Experimental Study of Air-side Heat Transfer and Pressure Drop of Evaporator for Refrigerator Unit," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 1, pp. 42-47, 2019.
12. Hwang, S. W., "A Comparison Study of Performance due to the Oil-cooler Fin Shape for Diesel Engine using Numerical Analysis," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 1, pp. 1-7, 2019.
13. Jang, B. M., Cho, D. H., "A Study on the Flow Characteristics around Vertical Wall with Flap," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 2, pp. 248-253, 2019.
14. Kang, H. J., Lee, H. S., "A Study on Heating and Cooling Performance Characteristics of Heat Meter for Water Source Heat Pump System," Journal of the Korean Society of Mechanical Technology, Vol. 21, No. 2, pp. 321-326, 2019.
15. Kim, B. H., Jung, D. S., "Flow Analysis for the Sludge Pneumatic Dehydrator with Cyclone Type," Journal of the Korean Society of Manufacturing Process Engineers, Vol. 8, No. 4, pp. 1-6, 2009.